Scour – Northern Drain – Main Basin

Culvert from Northern Drain to Main Basin 95% Blocked - Outlet

Culvert from Northern Drain to Main Basin 95% Blocked - Outlet

Culvert from Northern Drain to Main Basin Inlet - Clear

Culvert from Northern Drain to Main Basin
Inlet – Clear
Outlet – 95% Blocked

Culvert from Northern Drain to Main Basin
Silt build up – Outlet Side

Scour & Erosion
Main Basin – North Western

Scour & Erosion
Main Basin – North Western

Scour & Erosion
Main Basin – Western Side

Silt
Culvert Inlet – Western Side
Main Basin

Silt Built up
Culvert Outlet – Western Side
Main Basin

Culvert from Western Drain to Main Basin
95% Blocked - Outlet

Check Dams

DRAINAGE CONTROL TECHNIQUE

Low Gradient	✓	Velocity Control	✓	Short Term	✓
Steep Gradient		Channel Lining		Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	[1]

[1] Though not generally considered as permanent structures within drainage channels, rock check dams have been used in stormwater treatment swales to improve retention time and increase sedimentation. Permanent rock check dams can also be used to form a stable, terraced invert within mild-sloping (<10%) table drains. Permanent checks dams, however, can cause mowing problems.

Symbol (refer to Table 2)

Photo 1 – Sandbag check dams

Photo 2 – Rock check dam

Key Principles

1. The primary function of check dams is to control flow velocities within unlined drains. Most check dams, however, will also trap small quantities of sediment, thus allowing these structures to act as both *drainage* and *sediment* control devices.
2. Sediment control does **not** have to be considered a performance objective in all cases.
3. Hydraulic performance is governed by the height and spacing of the dams. The spacing of check dams down a drain varies with the slope of the drain and the height of each dam.
4. It is critical to ensure the check dams do not cause flow to unnecessarily spill out of the drain possibly resulting in flooding or erosion problems.
5. The crest of the check should be curved such that flow first spills over the centre of the dam. Use of a flat crest profile can cause erosion (rilling) down the banks of the drain.

Design Information

Table 2 provides guidance on the attributes and typical usage of various types of check dams, it is summarised in Table 1.

Table 1 – Summary of technique selection

Type of check dam	Typical conditions of use
Fibre rolls, Triangular & Sandbag check dam	• Drains less than 500mm deep
Rock check dam	• Drains more than 500mm deep
Compost-filled bags	• Situations where velocity control and enhanced stormwater treatment (filtration and adsorption) is required

Table 2 – Typical use of the various types of check dams

Technique	Code	Symbol [1]	Attributes and typical usage
Fibre rolls	FCD	→ FCD →	• Biodegradable (jute/coir) logs. • Used in wide, shallow drains where the logs can be successfully anchored down. • Used in locations where it is desirable to allow the fibre roll to integrate into the vegetation, such as vegetated channels. • Can be used as a minor sediment trap.
Rock check dams	RCD	→ RCD →	• Constructed from 150 to 300mm rock. • Best used **only** in drains at least 500mm deep, with a gradient less than 10%. • Should only be used in locations where it is known that they will be removed once a suitable grass cover has been established. • Can also be used as a minor sediment trap.
Recessed rock check dams	RRC	→ RRC →	• Constructed from minimum 200mm rock. • Used in wide, shallow, high velocity channels to prevent uncontrolled gully erosion during the revegetation period. • These are specialist hydraulic structures requiring specialist knowledge for their proper usage.
Sandbag check dams (including compost-filled bags)	SBC	→ SBC →	• Sandbags are typically filled with sand, aggregate, gravel, or compost. • Compost filled bags are considered to provide improved water treatment through filtration and adsorption. This system included compost-filled *Filter Socks*. • Typically used in drains less than 500mm deep, with a gradient less than 10%. • These check dams are typically small (in height) and therefore less likely to divert water out of the drain. • Can be used as a minor sediment trap.
Stiff grass barriers	SGB	▬ SGB ▬	• Requires long establishment times. • Typically used as a component of long-term gully stabilisation in rural areas. • Most suited to sandy soils. • Can be used as a minor sediment trap.
Triangular ditch checks	TDC	→ TDC →	• Manufactured from re-useable, porous, solid frame, PVC mesh. • Commonly used to stabilise newly formed, wide, shallow drains. • Used in drains with less than 10% gradient. • Can be used as a minor sediment trap.

[1] The check dam symbol is usually not used on ESC plans; instead the use of check dams is normally specified within technical notes listed on the plans. A table may be included within the ESCP to provide details on the type of check dam used at specific locations within the site.

Typical maximum channel gradient of 10% (1 in 10). Preference should be given to the use of a suitable channel lining if the drain or chute is steeper than 10%.

Check dams are spaced down the drain such that the crest of the check dam is level with the toe of the immediate upstream check dam (as shown in Figures 1).

Maximum recommended crest height of around 500mm. Check dams with a height exceeding 500mm should be checked for hydraulic stability.

Maximum slope of the face of rock check dams is 2:1 (H:V). For check dams higher than 500mm, the slope of the **downstream** face may need to be significantly flatter than a 2:1.

The crest of the check dam should be curved such that flow first spills over the centre of the dam. Ideally, the crest of each dam should be at least 150mm lower than the bank elevation at the outer edges of the structure.

The purpose of a curved crest profile is to:

- minimise the quantity of water bypassing around the edge of the check dam; and
- to concentrate flow into the centre of the channel.

Use of a flat crest profile can cause erosion (rilling) down the banks of the drain.

For sandbag check dams placed in shallow profile drainage channels, such as some table drains, it may be necessary to remove one or two sandbags from the centre of the structure (refer to Photo 3) to promote flow at the centre of the drain. The sandbags may also need to be placed in a curved (concave) horizontal profile to minimise flow bypassing around the ends of the dam (this can also be seen in Photo 3).

Check dams should not be used to control erosion within drains formed from dispersive soil (Photos 9 & 10). In such cases, the exposed dispersive soil should be covered with non-dispersive soil, then stabilised with an appropriate channel liner.

In circumstance where the use of check dams could cause such a significant reduction in the drain's hydraulic capacity to force water out of the drain resulting in either traffic safety issues (table drains) or flooding of adjacent properties, then the design options are:

- select an appropriate channel lining such that the use of check dams within the drain will no longer be required;
- perform an appropriate hydraulic analysis on the check dams to ensure that adequate hydraulic performance of the drain is maintained (refer over-page for guidance on such hydraulic analysis).

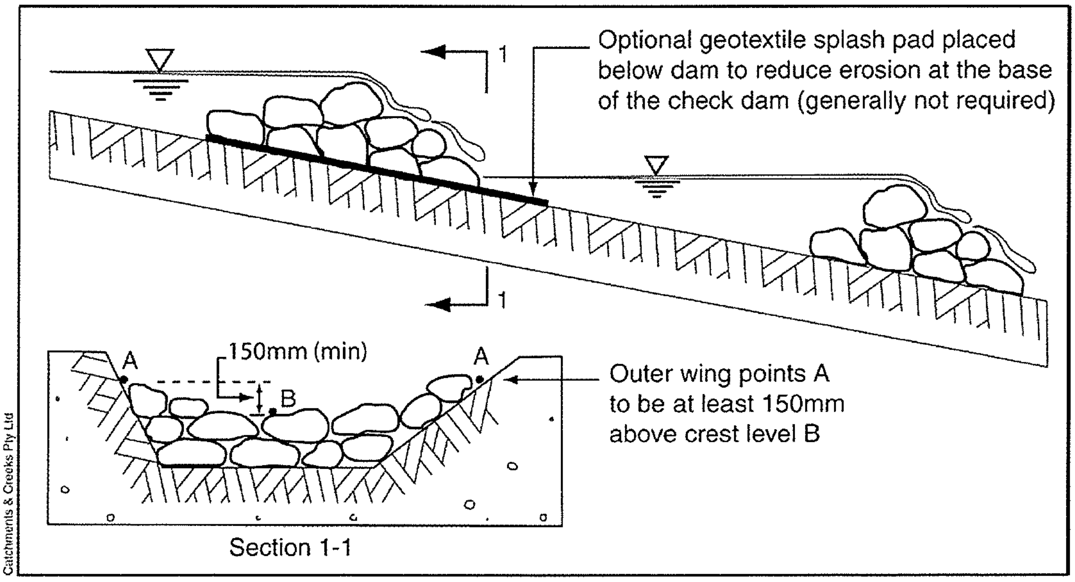

Figure 1 – Profile of temporary check dams

Photo 3 – Sandbag check dam

Photo 4 – Fibre rolls

Photo 5 – Triangular ditch checks

Photo 6 – Stiff grass barrier (background)

Photo 7 – Poor placement of rocks, note rocks are higher in centre of check dam

Photo 8 – Retained rock check dams can interfere with ongoing mowing

Photo 9 – Typical erosion problem when placed in dispersive soil

Photo 10 – Typical erosion problem when placed in dispersive soil

Erosion control at toe of check dams:

Erosion downstream of each check dam will be minimised if the dams are correctly spaced such that the crest of each dam is level with the toe of the nearest upstream dam.

Where necessary, the risk of erosion at the toe of each check dam may reduced by constructing each check dam on a sheet of geotextile fabric (e.g. filter cloth or woven fabric) that extends downstream of the dam a distance at least equal to the height of the dam (Figure 1).

Hydraulic design:

In general, a hydraulic analysis is not normally performed on check dams as their use should be restricted to those locations where they are unlikely to cause hydraulic problems. However, in circumstance where use of check dams could cause either traffic safety issues (table drains) or flooding of adjacent properties, then a hydraulic analysis will be required.

As a quick check, Table 3 can be used to assess the hydraulic capacity of a proposed check dam. Table 3 provides the maximum discharge for a given maximum water level (H) and check dam width (W). The table is based on a check dam with a **flat crested**, trapezoidal weir profile with side slopes of 1 in 2 (Figure 2) using Equation 1.

$$Q = 1.7\,W H^{1.5} + 2.5\,H^{2.5} \qquad \text{(Eqn 1)}$$

Table 3 – Assumed hydraulic capacity of check dam [1] (m^3/s)

Allowable upstream head (H) metres	Check dam flat crest width (W) metres				
	1.0	**1.5**	**2.0**	**2.5**	**3.0**
0.1	0.06	0.09	0.12	0.14	0.17
0.2	0.20	0.27	0.35	0.43	0.50
0.3	0.40	0.54	0.68	0.82	0.96
0.4	0.69	0.90	1.12	1.33	1.55
0.5	1.05	1.35	1.65	1.95	2.25
0.6	1.49	1.89	2.28	2.68	3.07
0.7	2.03	2.53	3.02	3.52	4.02
0.8	2.66	3.27	3.88	4.48	5.09
0.9	3.39	4.11	4.84	5.57	6.29
1.0	4.22	5.07	5.92	6.77	7.62

[1] Hydraulics is based on a flat crested, trapezoidal weir profile with a side slope of 2:1 (H:V).

If the side slopes of the drainage channel is not 2:1 (H:V), then the appropriate weir equation is:

$$Q = 1.7\,W H^{1.5} + 1.26\,m\,H^{2.5} \qquad \text{(Eqn 2)}$$

where:

Q = Discharge passing over the check dam (m^3/s)

W = Crest width of the check dam crest (m)

H = Upstream water head relative to the crest of the check dam (m)

m = Channel side slope, m:1 (H:V)

Both Equations 1 and 2 assume a flat crested weir profile; however, it is a requirement that check dams must have a curved crest with a minimum 150mm depression (Figure 1). Thus, Equations 1 and 2, and Table 3, all <u>overestimate</u> the hydraulic capacity of check dams. Therefore, a conservative design approach is required.

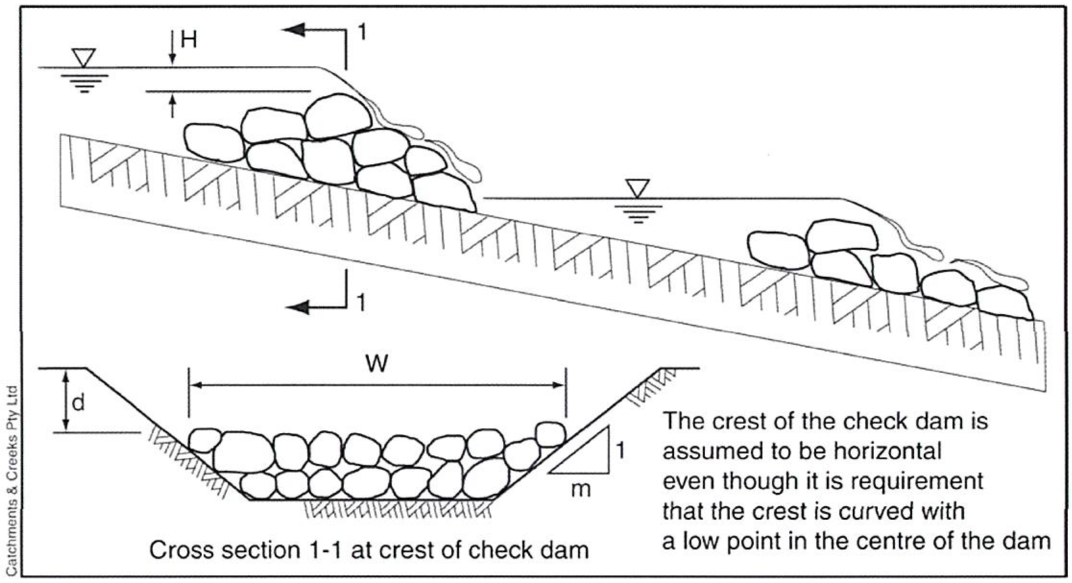

Figure 2 – Assumed check dam profile for Equations 1 and 2

Design example 1:

Determine the maximum allowable height of rock check dams placed along a channel that has a base width of 1.0m and side slopes of 3:1 (m:1). The total depth of channel is 0.7m and the required flow rate is 0.4m^3/s. (note; this is the required allowable flow rate during the operational phase of the check dams, which may be different from that specified for design of the drain, especially if the drain is a permanent structure).

Solution:

The difficulty here is that the crest width of the check dam (W) will vary with the height of the dam, which is the variable that we are trying to determine. Therefore we will need to answer this question using a trial and error process.

As a first guess, try the maximum recommended check dam height of 0.5m. This means the maximum allowable upstream head (H) is 0.7 - 0.5 = 0.2m.

Thus the check dam crest width is:

$$W = \text{(bed width of channel)} + 2.\text{(side slope, m)}.\text{(height of check dam)}$$

$$W = 1.0 + 2(3)(0.5) = 4\text{m}$$

Using Equation 2, the maximum allowable discharge (i.e when H = 0.2m) is:

$$Q = 1.7\,W\,H^{1.5} + 1.26\,m\,H^{2.5} = 1.7(4)(0.2)^{1.5} + 1.26(3)(0.2)^{2.5} = 0.68\text{m}^3/\text{s} > 0.4\text{m}^3/\text{s}$$

Therefore the available hydraulic capacity of 0.68m^3/s is greater than the required hydraulic capacity of only 0.4m^3/s, thus the check dam height will be limited to the maximum recommended height of 0.5m.

Design example 2:

Determine the maximum allowable flow rate (Q) for a check dam in a drainage channel with side slopes of 2:1; check dam crest width, W = 2m; and maximum allowable upstream hydraulic head, H = 0.4m.

Solution:

Given the side slope is 2:1 (H:V), we can use Table 3 to answer this question. From Table 3 it can be seen that the maximum allowable flow rate is around, Q = 1.12m^3/s (note, Table 3 overestimates the available hydraulic capacity if the check dam has a curved, U-shaped crest).

Stiff grass barriers:

Stiff grass barriers (Figure 3) are typically used as a component of long-term gully stabilisation in rural areas. The most common grass species is the sterile form of vetiver zizanoides.

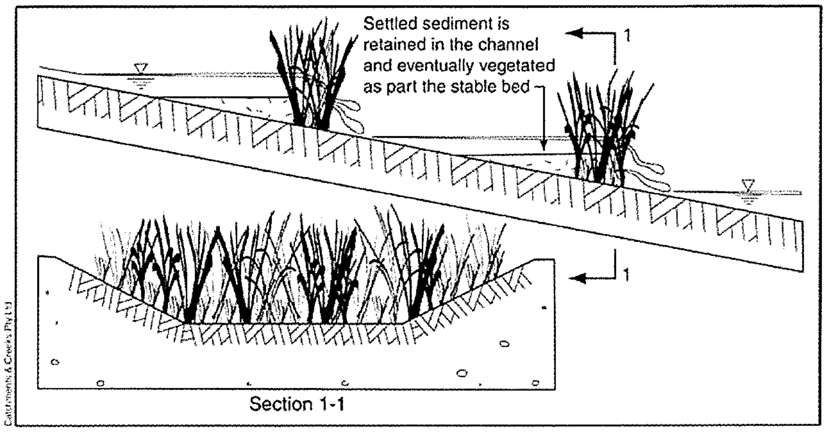

Figure 3 – Stiff grass barriers

Recessed rock check dams:

Recessed rock check dams can be used to:

- Control flow velocities in wide, shallow channels (typically less than 500mm deep) where other types of check dams, such as sandbags, are expected to wash away. In such cases the check dams are partially recessed into the channel bed.
- Control flow velocities and erosion in high velocity channels where a large rock size (greater than 300mm) is required, but the channel is too shallow to accommodate such rocks being placed directly on the channel bed. In such cases the check dams are partially recessed into the channel bed.
- Limit potential future gully erosion within constructed waterways and vegetated drainage channels. In such cases the rocks are recessed into the bed of the channel so that the top of each check dam is just below the bed of the channel (Figure 4).

In this latter case, the recessed rock checks (these are technically not 'dams') are used as an 'insurance policy' against possible future channel erosion, especially during the vegetation establishment phase when the channel roughness is significantly less than the assumed ultimate condition. The intension is to limit the extent and depth of any channel erosion between each recessed check structure. If erosion does not occur, then the check dams remain buried and incorporated into the stable channel profile.

Following installation of the recessed rock checks, the rocks are covered with soil (including the filling of all voids) and vegetated to fully incorporate the rock into the channel.

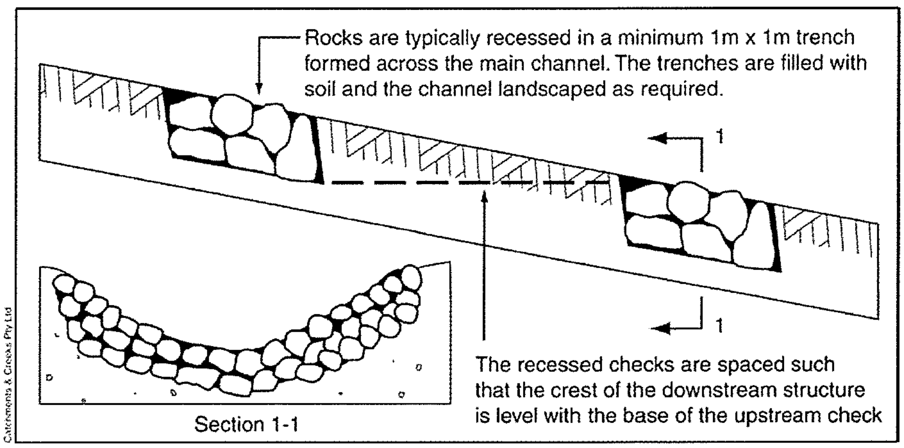

Figure 4 – Fully recessed rock check dams

Description

Check dams can be constructed from semipervious or impervious materials, typically rock or sandbags filled with a variety of porous materials.

Check dams should **not** be constructed from straw bales.

Rock check dams may be recessed into the channel bed to allow the use of larger sized rock, and/or to limit the crest height of the dams.

Purpose

Used to reduce flow velocity and the resulting erosion within:

- temporary, open earth channels;
- permanent vegetated channels during the plant establishment phase.

Check dam can also provide limited sediment trapping ability, but usually as a secondary function.

Limitations

Check dams are normally limited to mild sloping channels less than 10% grade.

Typical maximum height of 500mm.

Generally not used in watercourses. Instead, consider the used on *Sediment Weirs, Rock Filter Dams*, or formally designed rock weirs or drop structures.

Should not be placed directly on dispersive soils, or within drains cut into dispersive soils.

Advantages

Quick and inexpensive to install.

Low maintenance.

Disadvantages

Rock check dams can cause damage to grass cutting equipment if not removed from the channel after vegetation has been established (Photo 8).

Common Problems

Hydraulic problems often occur when rock check dams are specified in shallow drains.

Erosion can occur around the edges of the check dams, especially if installed with a flat crest.

Inappropriate spacing of the dams. This usually results from inadequate installation information supplied on the ESCPs.

Special Requirements

If soils are highly erosive (but not dispersive), then consider the use of an underlying geotextile skirt placed under each check dam (Figure 1).

Appropriate care must be taken to prevent failure caused by water undermining or bypassing round the dams.

Site Inspection

Check for invert erosion within the channel being stabilised with check dams.

Ensure the type of check dam is appropriate for the flow conditions and type of drainage channel.

Ensure the crest is below the height of the outer wings of the dams (refer to Figure 1).

Ensure the dams are appropriately spaced.

Materials

- Rock: 150 to 300mm nominal diameter, hard, erosion resistant rock. Smaller rock may be used if suitable large rock is not available.
- Sandbags: geotextile bags (woven synthetic, or non-woven biodegradable) filled with clean coarse sand, clean aggregate, straw or compost.

Installation

1. Refer to approved plans for location and installation details. If there are questions or problems with the location or method of installation, contact the engineer or responsible on-site officer for assistance.
2. Prior to placement of the check dams, ensure the type and size of each check dams will not cause a safety hazard or cause water to spill out of the drain.
3. Locate the first check dam at the downstream end of the section of channel being protected. Locate each successive check dam such that the crest of the immediate downstream dam is level with the toe of the check dam being installed.
4. Ensure the channel slope is no steeper than 10:1 (H:V). Otherwise consider the use of a suitable channel liner instead of the check dams.
5. Construct the check dam to the dimensions and profile shown within the approved plan.

6. Where specified, the check dams shall be constructed on a sheet of geotextile fabric used as a downstream splash pad.
7. Each check dam shall be extended up the channel bank (where practicable) to an elevation at least 150mm above the crest level of the dam.

Maintenance

1. Inspect each check dam and the drainage channel at least weekly and after runoff-producing rainfall.
2. Correct all damage immediately. If significant erosion occurs between any of the check dams, then check the spacing of dams and where necessary install intermediate check dams or a suitable channel liner.
3. Check for displacement of the check dams
4. Check for soil scour around the ends of each check dam. If such erosion is occurring, consider extending the width of the check dam to avoid such problems.
5. If severe soil erosion occurs either under or around the check dams, then seek expert advice on an alternative treatment measure.
6. Remove any sediment accumulated by the check dams, unless it is intended that this sediment will remain within the channel.
7. Dispose of collected sediment in a suitable manner that will not cause an erosion or pollution hazard.

Removal

1. When construction work within the drainage area above the check dams has been completed, and the disturbed areas and the drainage channel are sufficiently stabilised to restrain erosion, all temporary check dams must be removed.
2. Remove the check dams and associated sediment and dispose of in a suitable manner that will not cause an erosion or pollution hazard.